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Historical Role of Fire in Pinyon-Juniper Woodlands
Walker River Watershed Project
Bridgeport Ranger District

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HISTORICAL ROLE OF FIRE IN PINYON-JUNIPER WOODLANDS

WALKER RIVER WATERSHED PROJECT

BRIDGEPORT RANGER DISTRICT

A REPORT

Prepared by George E. Gruell

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THE HISTORICAL ROLE OF FIRE IN PINYON-JUNIPER WOODLANDS
WALKER RIVER WATERSHED PROJECT
BRIDGEPORT RANGER DISTRICT

GEORGE E. GRUELL

INTRODUCTION

Tree stems bearing fire scars and charred wood indicate that historically fire was an important factor influencing succession in pinyon-juniper woodlands of Nevada and eastern California. Past fires can be dated by study of fire scars on tree rings. However, because of the low incidence of fire scars in pinyon-juniper woodlands, little is known about the frequency and intensity of these fires. In contrast to mixed conifer forests where fire scars are common, the relatively low numbers of fire scars in pinyon-juniper restricts our ability to interpret fire history (Gruell 1997). Previous studies adjacent to the Great Basin suggest a history of recurrent fires on productive big sagebrush-perennial grass sites now encroached by western juniper (*Juniperus occidentalis*) (Burkhart and Tisdale 1976, Young and Evans 1981). Chappel (1997) reports a mean fire interval of 50 years for 4 pinyon-juniper sites on Monroe Mountain south of Richfield, Utah. This fire interval estimate was considered conservative. Fire-scarred pinyon pine (*Pinus edulis*) of Great Basin National Park in eastern Nevada suggested an historic mean fire interval of less than 20 years on northerly exposures and sites that produced an abundance of light fuels. Rocky terrain with low potential for fire spread burned at longer intervals (Gruell et al. 1995). Fire history studies in mixed conifer on the east slope of the Sierra Nevada suggest pre-1900 fire intervals of 4-21 years (Rice 1988, 1990; Stephens 1996; Taylor 1996).

STUDY AREA

This study was conducted in the Walker River Watershed Project, an area encompassing 392,750 acres inclusive of the east slope of the Sweetwater Mountains, the Pine Grove Hills, and the west slope of the Bodie Hills. Elevations range from 5,600 feet on the East Walker River to 11, 673 feet at Mt.

Patterson in the Sweetwater Mountains. Pinyon pine dominates the landscape. Scattered juniper is intermixed with pinyon, being primarily found on south slopes and dry sites at lower elevations. As widely reported elsewhere in the Great Basin (Cottam and Stewart 1940, Christensen and Johnson 1964, West 1984, Tausch et al. 1981, Eddleman and Jaindl 1994) current stands exhibit an enormous increase in tree density and crown cover. This dynamic increase has resulted in displacement of herbs and shrubs (Tausch et al. 1981, West 1988). Closed stands in the Little Frying Pan locality showed a sparse understory and low vigor (Meeuwig and Budy 1979). Mining activity starting in 1860's resulted in the removal of trees in portions of the Walker River Watershed Project area (Paher 1970, Kersten 1964). The erection of a ten stamp mill in 1907 in the Masonic Mining District (Paher 1970) created a demand for wood in this region.

Sagebrush (*Artemisia spp.*), Antelope bitterbrush (*Purshia tridentata*), rabbitbrush (*Chrysothamnus spp.)* and Anderson peachbrush (*Prunus andersonii*) constitute the more common shrubs associated with pinyon-juniper. Snowberry (*Symphoricarpos spp.*), gooseberry (*Ribes spp.*), Woods rose (*Rosa woodsii*), serviceberry (*Amelanchier alnifolia*) and snowbrush ceanothus (*Ceanothus velutinus*) occur locally, forming minor components of the shrub cover. Curlleaf mountain-mahogany (*Cercocarpus ledifolius*) is found in localized stands. The herbaceous component is characteristically sparse except on sites where competition from woody vegetation is minimal and there is ample soil moisture.

The continental climate in this region is characterized by cold, dry winters and warm, dry summers. Annual precipitation at Bridgeport (6,500 feet), over the 22 year period 1958-1979, averaged 9.48 inches (National Climatic Data Center 1997). Yearly snowfall accumulations are variable, being strongly influenced by elevation and aspect. Lightning storms occurring between May and September commonly ignite wildfires. Since 1960, 266 wildfires have been suppressed in the Walker River Watershed Project area. Only 5 of these have been over 100 acres. The largest, 900 acres occurred in 1996.

American Indians, the more recent of which were the Piaute tribe, occupied the project area for at least 10,000 years (K. Fowler 1997 pers. Comm.). Their residency is evidenced by an abundance of obsidian chips, rock rings at food storage and habitation sites, and rock enclosures used in capturing big game. Living under adverse conditions, Indians utilized various means to survive. This included intentional firing of the landscape for a variety of reasons including production of grass seed and other food plants, stimulation of willow shoots used for basket-making, immobilizing crickets and grasshoppers, driving jackrabbits (*Lepus spp.*), clearing campsites, and signaling between bands (Cooper 1961, Stewart 1963, Moore 1972, Lewis 1985, Gruell 1985).

Beginning in the 1850's, European-Americans began to settle lands occupied by Indians. Placer mining was underway in the Dog Town district south of Bridgeport in 1857 (Fletcher 1987). The Sweetwater Ranch and other ranches in Big Meadows were taken up by 1861. In the mid-1860's, various ranges were stocked with cattle and meat was being supplied to the mining camps. Migratory sheep bands made their appearance in the 1880s. By the turn of the century, 200,000 sheep were being grazing in the Mono Basin (Fletcher 1987), while sheep had replaced cattle at the Sweetwater Ranch (B. Romero 1997 pers. Comm.). In the early 1860's, no longer able to depend on traditional food sources, the Indians were forced to become increasingly dependent on EuroAmerican settlers.

METHODS

Collection of fire scars from pinyon and Jeffrey pine (*Pinus jeffreyi*) were made during June-July 1997 in the Little Frying Pan and Desert Creek drainage's of the Sweetwater Mountains, Nye Canyon and a nameless canyon on the northeast side of Bald Mountain in the Pine Grove Hills, and the Masonic Gulch locality in the Bodie Hills. Random searches were made until three or more trees bearing fire scars were located. The size of the search area varied with fire scar availability. Few fire-scarred pinyon were found in areas where the trees were in a seral stage of growth. Those bearing fire scars

were widely distributed on fire resistant sites. Excepting for 2 trees in the Pine Grove and Bodie Hills, fire scarred Jeffrey pine were confined to an isolated stand growing on sites susceptible to fire in the Little Frying Pan drainage. (Several Jeffrey pine stumps in Desert Creek showed evidence of multiple fires, but they were too badly burned to be sampled). Trees with well-developed scars were sampled by removing a cross-section from each with a chain saw. Between 4 and 9 samples were collected from each area for a total of 22. These samples were later sanded smooth, examined under 10X-20X magnification, and the scars dated by counting annual rings. The geographical position of each sample tree was plotted by means of a Global Positioning Satellite instrument (fig. 1).

Emphasis was placed in the Little Frying Pan area because the Jeffrey pine intermixed with pinyon-juniper carried a high complement of fire scars. This presented a unique opportunity to collect more comprehensive data on fire frequency in pinyon-juniper. Although Jeffrey pine grows in association with pinyon-juniper on the lower east slope of the Sierra Nevada, they are not normally present in Great Basin woodlands. They are an excellent recorder of fire since they are long-lived, fire resistant, have clear annual ring growth, and occupy sites that were fire susceptable. Six fire-scarred Jeffrey pine (4 live trees and two stumps) and 3 pinyon were sampled (fig. 2). Although the cambial ring year of the stumps was unknown, historical accounts (Kerston 1964, Paher 1970) suggest these trees were cut in the 1860's. An 1868 cutting date was assigned to the stumps after synchronizing their most recent fire scars with those on nearby live trees.

A master fire chronology was developed for the Little Frying Pan area according to the geographical position of sample trees. Questionable fire years were adjusted with those considered the more probable years of scarring (Arno and Sneck 1977). These dates were not verified by dendrochronological cross dating (Stokes and Smiley 1968). The probability of false rings, missing rings, and the deteriorated state of counting surfaces reduced the accuracy of ring counts on portions of some samples. Thus, the fire

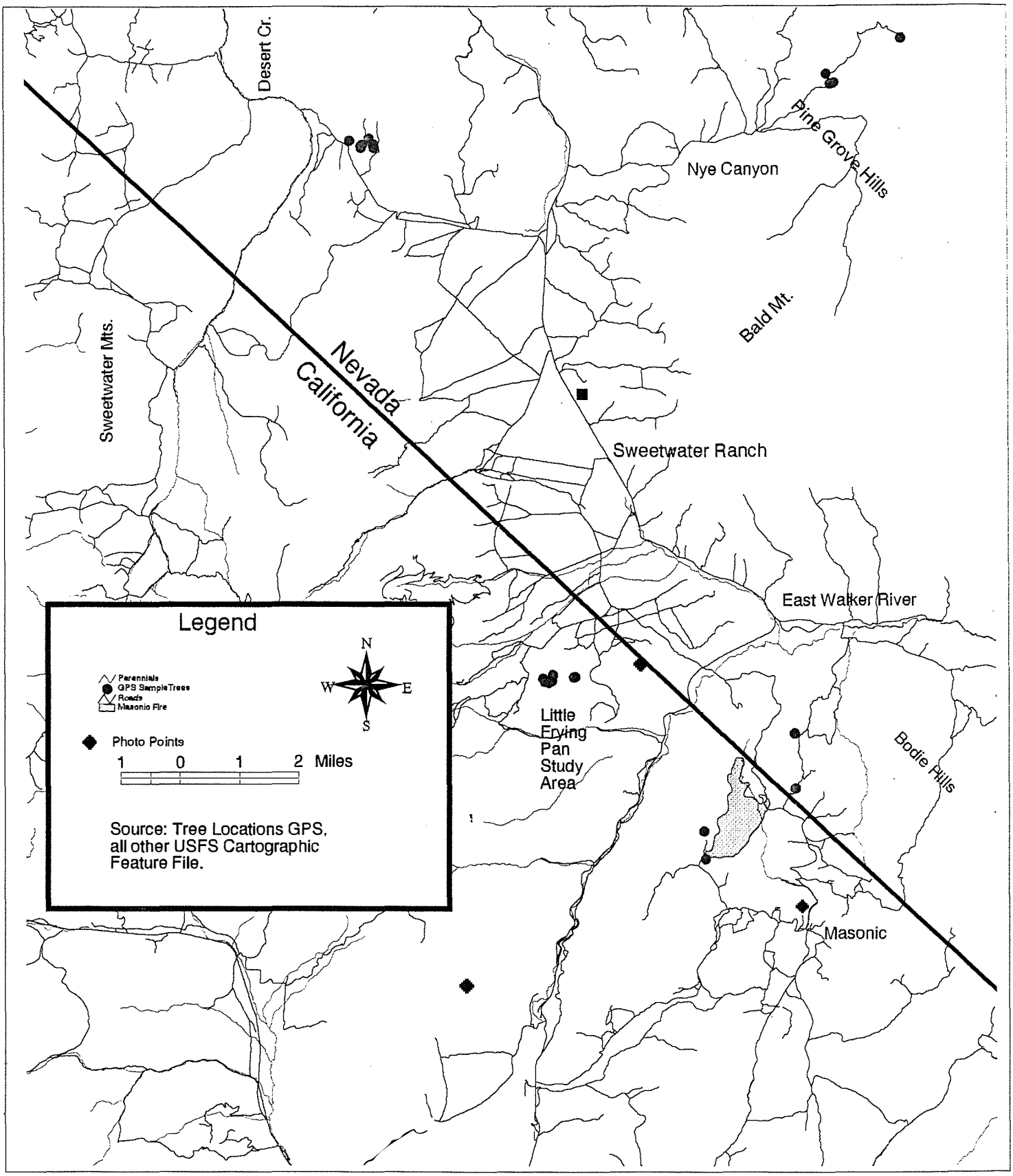

Fig. 1 - Location of fire-scared sample trees and photo points in Walker watershed project.

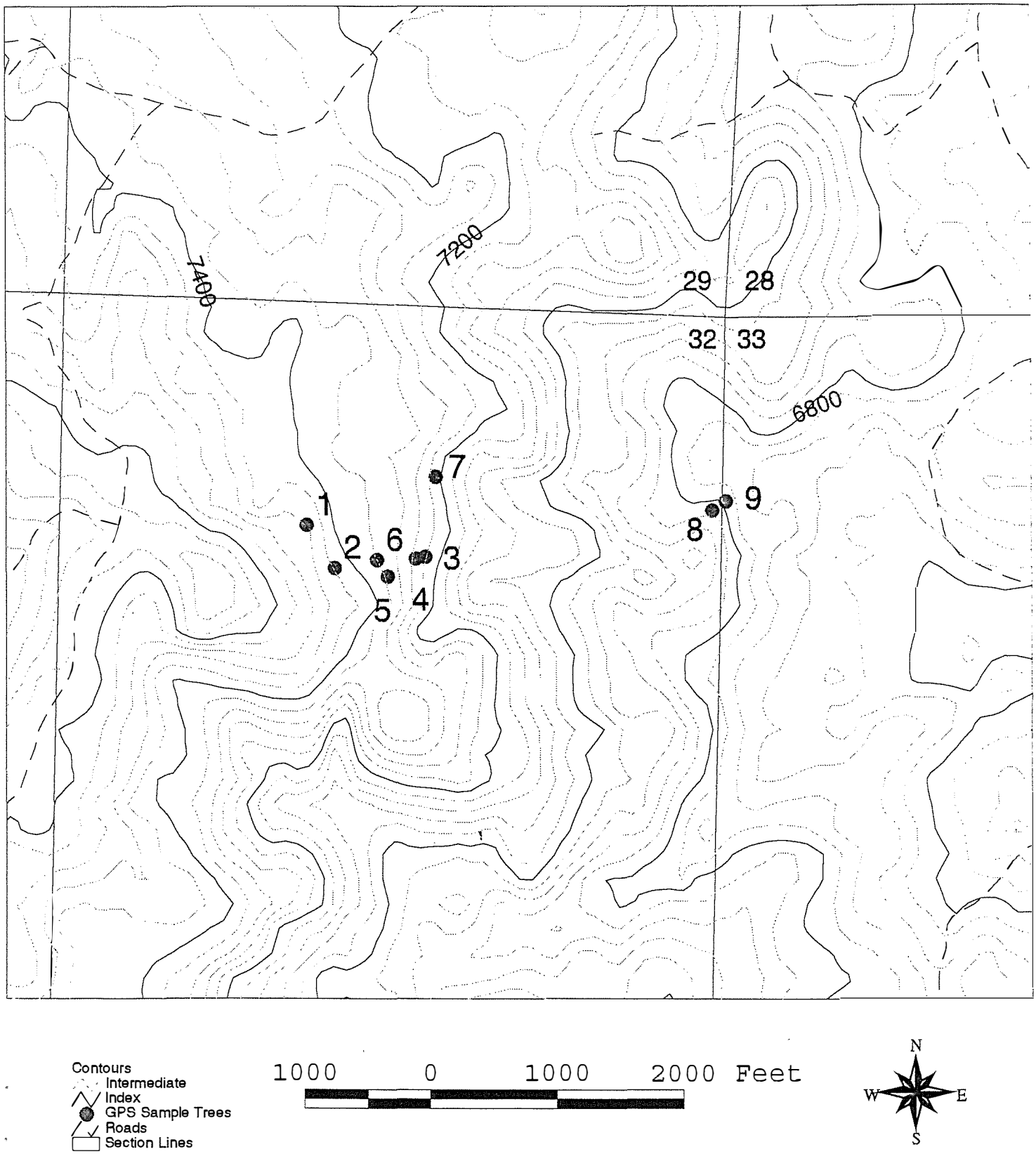

Fig. 2 - Location of fire-scared trees in Little Frying Pan.

history statistics are considered reasonably accurate but not precise. A master fire chronology was not prepared for the Desert Creek, Bald Mountain and Masonic areas because of the minimal number of fire scars on the samples collected.

Three historical photographs taken during the period 1899-1906 were re-photographed in the Bodie Hills, and the east slope of the Sweetwater Mountains. These scenes aided interpretations of plant succession by providing visual evidence of composition and structure during early stages of European settlement.

RESULTS AND DISCUSSION

Little Frying Pan Study Area

Sampling of 6 Jeffrey pine and 3 pinyon pine produced a 208-year master fire chronology dating from 1687 to 1895 (table 1). A total of 51 fire scars formed on 9 trees during this period. At least 27 fire years are represented. This suggests that fires burned somewhere within the < 100-acre study area every 8 years. From 1-5 fires were recorded on sample trees during each of the 27 fire years. Fire scars on 5 of the 6 Jeffrey pine samples suggested extensive burning in 1857. Extensive burning is also indicated in 1864, 1844, 1801, and 1785 when 3 trees were scarred in each of these years. Fires were particularly frequent during the 1840's, 1850's, and 1860's when 17 of the 51 scars formed. The longest fire intervals (30, 28, and 37 years) were indicated by sample no. 6, a deeply charred stump. However, these intervals likely resulted from the loss of some intervening fire scars since it is evident that much of the scarred surface had been consumed. They are also longer then the fire intervals on other samples.

Tree no. 7 exhibited the most extensive and reliable record, having been scarred 12 times over a period of 101 years. Growing on a productive site in a steep, narrow canyon, the potential for fire spread was high. Having been scarred at a relatively young age, it was susceptible to repeated scarring. On two occasions between 1841 and 1844, and again between 1861 and 1864 it recorded fires at 3 year intervals.

Table 1. Master fire chronology for the Little Frying Pan sampling area showing the number of trees scarred during each fire year.

Est. Fire Year	Species	J.P.	J.P.	J.P.	J.P.	J.P.	P	J.P.	P	P	Total Scars
	Tree No.	1	2	5	6	3	4	7	8	9	
1895		-	-	-	-	-	-	X	-	X	2
1889		X	-	-	-	-	-	-	-	-	1
1876		-	-	-	-	-	-	X	-	-	1
1872		-	-	-	-	X	-	-	-	-	1
1864		-	X	X	-	-	-	X	-	-	3
1861		-	-	-	-	-	X	X	-	-	2
1857		X	X	-	X	X	-	X	-	-	5
1852		-	X	-	-	-	-	X	-	-	2
1844		-	-	X	X	-	-	X	-	-	3
1841		-	-	-	-	X	-	X	-	-	2
1837		-	X	-	-	-	-	-	-	-	1
1830		-	X	-	-	-	-	X	-	-	2
1822		-	-	X	-	-	-	-	-	-	1
1818		-	X	-	X	-	-	-	-	-	2
1813		X	-	-	-	-	-	X	-	-	2
1809		-	X	-	-	-	-	X	-	-	2
1801		-	X	-	X	X	-	-	-	-	3
1794		X	-	-	-	-	-	X	-	-	2
1785		-	X	-	X	X	-	-	-	-	3
1779		-	-	-	X	-	-	-	-	-	1
1768		X	X	-	-	-	-	-	-	-	2
1764		-	-	-	-	-	-	-	X	-	1
1749		X	-	-	X	-	-	-	-	-	2
1739		-	X	-	X	-	-	-	-	-	2
1734		X	-	-	-	-	-	-	-	-	1
1724		-	-	-	X	-	-	-	-	-	1
1687		-	-	-	X	-	-	-	-	-	1

J.P. – Jeffrey Pine.
P – Pinyon Pine.

Desert Creek, Bald Mountain, and Masonic Study Areas

Fire scar-sampling data from the upper Desert Creek, Bald Mountain, and Masonic study areas are presented in table 2. All trees sampled were pinyon excepting 2 Jeffrey pine that were growing in isolated stands on infertile soils bare of vegetation. In contrast to the multiple fire scarred Jeffrey pine in the Little Fry pan study area, these stands contained only 2 trees with intact fire scars. The Bald Mountain tree recorded a single fire, while the Masonic tree recorded 5 fires. This tree grew at the edge of the pinyon-juniper where fuel accumulations over many years subjected it to infrequent fire. Fire dates could not be established, since the year it died was not determined. Nonetheless, it was a valuable sample, having verified the occurrence of recurrent fire in pinyon-juniper.

Ten of the 14 pinyon collected in the 4 sample areas were over 300 years of age, while 3 exceeded 400 years. Excepting Masonic no. 1, these trees recorded only one fire each, thus demonstrating an extremely low susceptibility to scarring. The low susceptibility of pinyons to scarring is also indicated by the years that have elapsed since the last fire (range 82-248). Masonic no. 1 was the only pinyon bearing multiple fire scars. These data suggest the occurrence of 3 fires over a 164-year period up to 1832. Adjoining woodlands largely consist of relatively young trees (< 130 years), reflecting the influence of frequent fire.

The Masonic sample no. 2 was the only tree bearing a post-1900 fire scar. A 1915 fire date seems to correlate with a burn mosaic of approximately 670 acres to the east that contains many down logs (fig. 1). The pre-fire stand consisted of scattered patches of trees distributed over rocky terrain that allowed the trees to resist light surface fires. By, the early 1900's the stand evidently had reached a successional stage vulnerable to high intensity fire. Charred wood suggests that some of the trees were dead at the time of the fire, thereby contributing to its intensity. Had the trees been alive, only the bark would have charred.

Repeat of Historical Photographs

The repeat photographs taken during this study visually demonstrate changes in the density of pinyon-juniper in the Walker River Watershed Project (plates 1-3). They are not, however, considered representative of pre-European settlement conditions. As suggested by the fire history data, the absence of fire for 2-4 decades or longer had allowed a substantial increase in tree cover by the turn of the century when the original photos were taken. At that time, the tree cover was patchy with communities of young trees occupying productive sites that had been swept by frequent fire in the past (plates 1a, 3a). The older trees were mostly distributed on steep, rocky and/or dissected topography where fuels were sparse (plates 2a, 3a). In contrast, the size and density of trees in current stands is significantly greater (plates 1b-3b). Openings that were virtually treeless before Euro American settlement are now heavily encroached by pinyon, while the interspaces in established stands have been filled by young trees.

CONCLUSION

While fire scar evidence in pinyon-juniper is much less abundant and less readily apparent than in ponderosa and Jeffrey pine stands, the samples taken from scattered Jeffrey pine growing in association with pinyon indicates that past fires played a critical role in pinyon-juniper woodlands of the project area. These woodlands were fire maintained until shortly after European settlement when removal of light fuels by livestock, followed later by aggressive fire suppression, drastically altered fire's role. Evidence of historical fire, is indicated by the widespread presence of charred wood and fire scarred pinyon.

As the data demonstrate, fire scarred pinyons verify fire occurrence, but are not a reliable indicator of fire frequency. This is evidenced by the marked contrast in numbers of fire scars on pinyon compared to those on Jeffrey pine in the Little Frying Pan study area. The 3 pinyon sampled had been scarred one time each, while the 6 Jeffrey pine carried between 3 and 12 fire scars each (total 48).

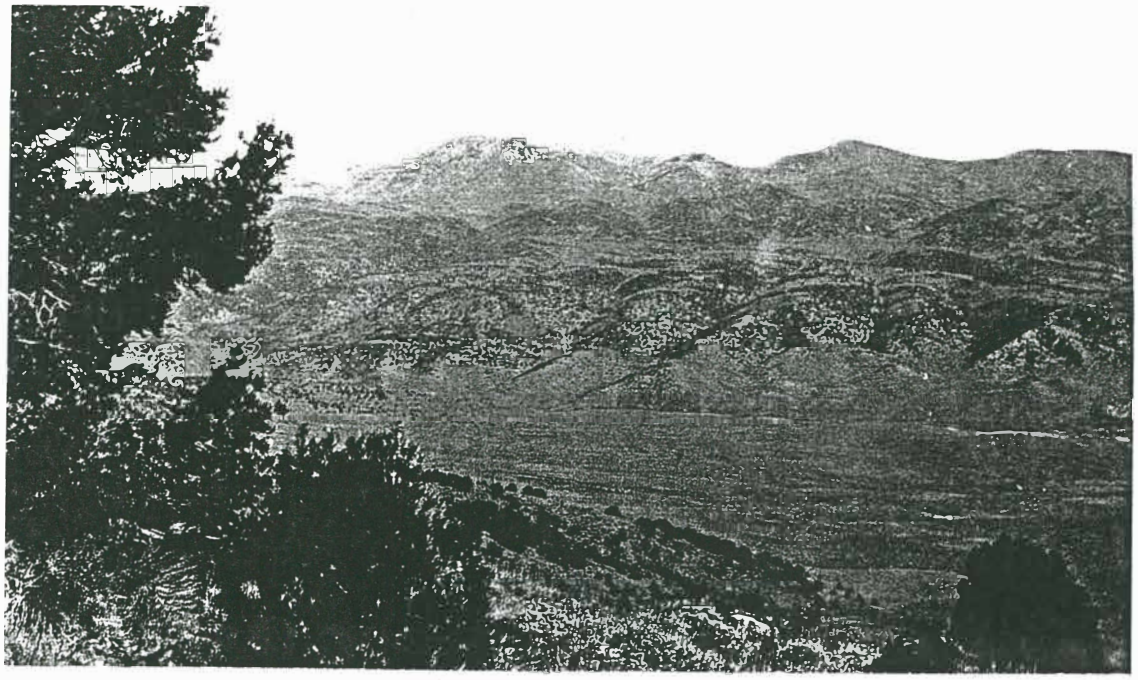

Plate 1a (1906) **Elevation 8,000 ft.**

Looking east-northeast at the western slope of the Bodie Hills from a point directly below Mt. Jackson in the Sweetwater Mountains. The pinyon-juniper on slopes below and in distance is in various stages of growth.
Photograph by W. D. Johnson, Courtesy United States Geological Survey, Denver.

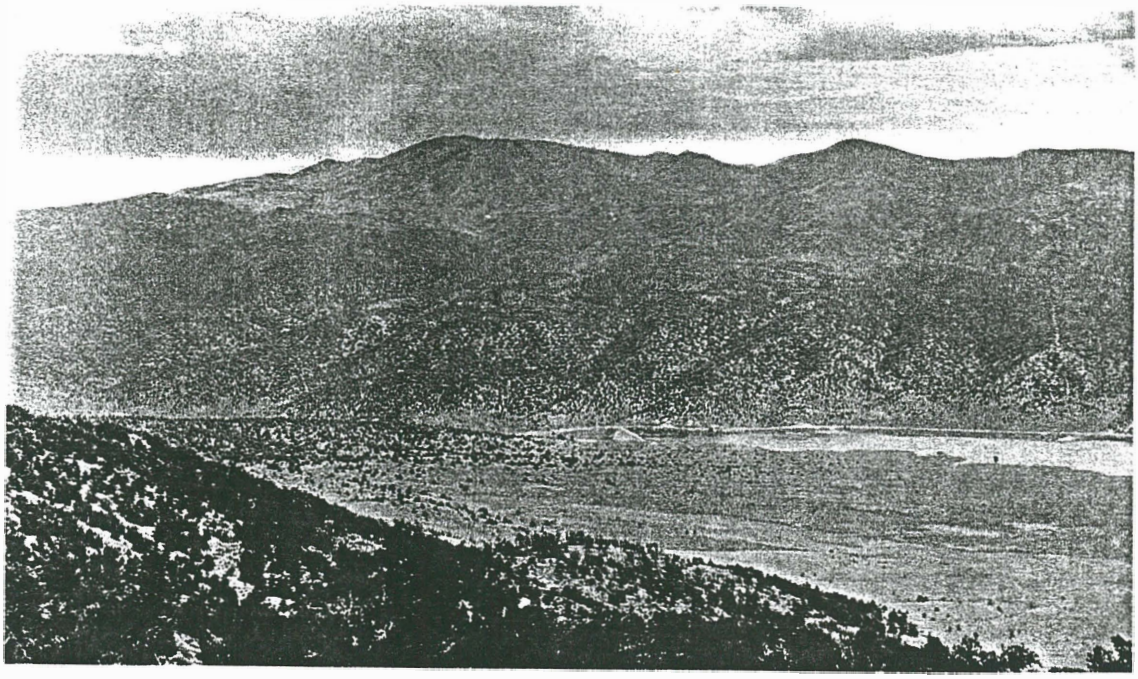

Plate 1b (July 28, 1997) **91 years later**

Heavy encroachment of pinyon made it necessary to take this repeat photograph from an alternate position between 50 and 100 feet to the left of the original camera point. From here, a clear view was obtained by removing a large tree. The trees at bottom-center, on the slopes below, were killed in a 1996 wildfire. The tree cover in distance, composed largely of pinyon, shows marked increases.
Photograph by G. E. Gruell.

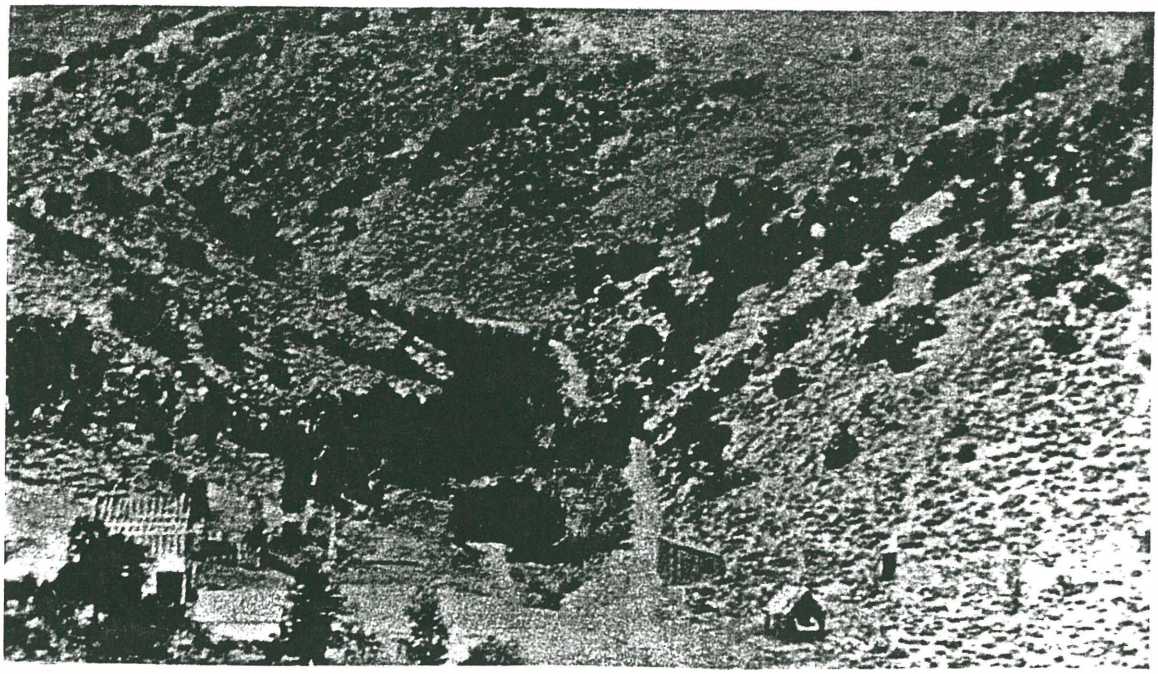

Plate 2a (1899) **Elevation 7,800 feet**

Looking south-southwest up the canyon at the Masonic (Middletown) mining camp. Aspen and willow occupy the riparian zone, while curlleaf mountain-mahogany are growing on rock outcrops. On the slopes at right, pinyon is distributed in a patchy pattern.
Photographer unknown. California-Nevada Boundary Survey photograph.

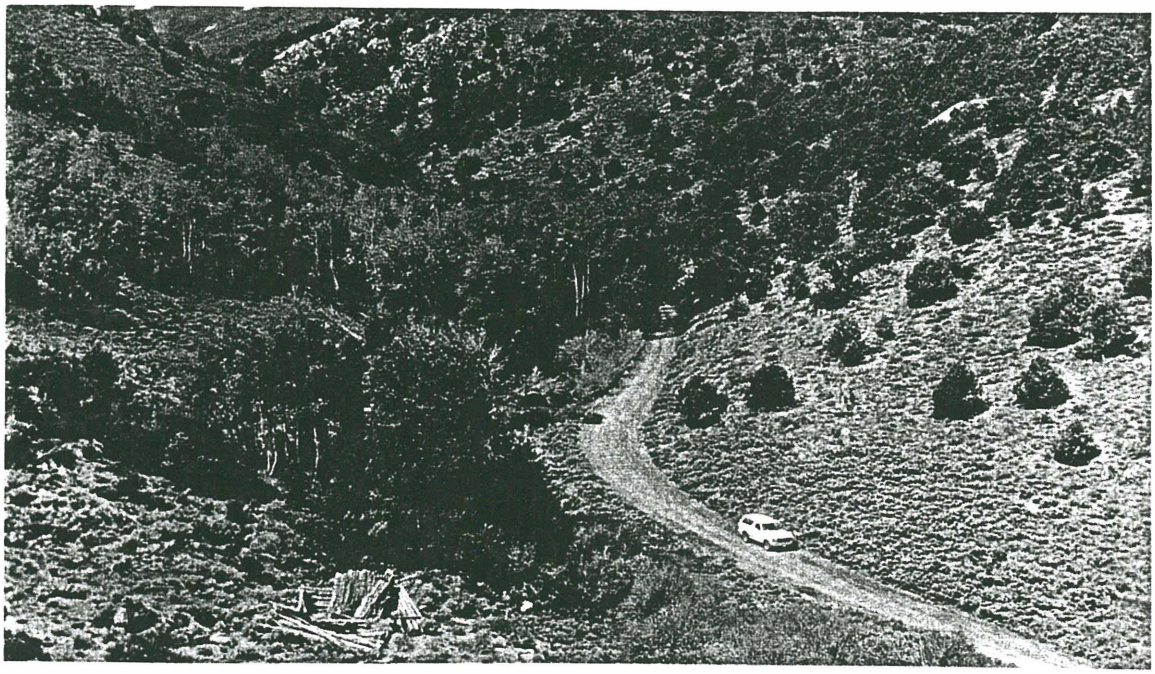

Plate 2b (June 3, 1997) **98 years later**

Although a poor match, the repeat photograph shows a pronounced increase of all woody vegetation. Pinyons on the slopes in distance now dominate sites that were formerly occupied by grass and shrubs. Tree densities in the older stands have increased.
Photograph by G. E. Gruell.

Plate 3a (1899) **Elevation 6,500 feet**

This west-northwest view was taken from monument 34 on the California-Nevada boundary. It is situated 2 miles due west of the Little Frying Pan study area. The tree cover is largely pinyon in various stages of growth. Note that the larger, older trees are primarily confined to the ridges. Photographer unknown. California-Nevada Boundary Survey photograph.

Plate 3b (June 5, 1997) **98 years later**

Heavy tree cover prevented the repeat photograph from being taken from the original camera point. The camera was moved about 60 feet left to an opening created by tree die-off. The widespread increase of pinyon in this scene is consistent with those depicted in plates 1 and 2. Photograph by G. E. Gruell.

Although growing in close proximity to Jeffrey pine, the pinyon failed to record frequent fire. This marked contrast in fire frequency reflects major differences in fuel loading on sites occupied by pinyon compared to those occupied by Jeffrey pine. The fire scarred pinyons were able to persist in microsites where fuels were sparse, and as a result they seldom were exposed to lethal heat. In contrast the Jeffrey pine grew on productive microsites that supported fine fuels of sufficient volume to carry fire. The Jeffrey pine sites are now largely covered by bare soil. This appears to be a function of excessive livestock grazing, shading, and uptake of soil moisture by woody vegetation.

Fire intervals of 8 years in the <100 acre Little Frying Pan study area provides convincing evidence that low intensity spreading fires ignited by lighting and Indians were an annual occurrence within the 392,750 acre project area prior to EuroAmerican settlement. This appears evident, considering an average of 7 lighting fires has been suppressed each year since 1960. The high frequency and low intensity of the historic fires suggests they were fueled by abundant perennial grass, the remnants of which are present today. Sites capable of producing contiguous surface fuels, including north slopes, canyon bottoms, and gentle topography were particularly susceptable to frequent fire. The relatively young age of trees and low incidence of charred wood (fragments), the presence of which required burning of heavy fuels, provide evidence of frequent low intensity fires on these sites. Tree establishment would have been inhibited since trees less than 50 years old are very susceptible to fire (Young and Evans 1981). As indicated by the data from fire scarred pinyon, infertile shallow soils and rocky sites-where there was a deficiency of fine fuels burned superficially. As suggested by the low incidence of fire scars on pinyon, fuels accumulated to a point where fire carried into fire resistant sites on rare occasions. This resulted in a mosaic of burned and unburned terrain. The end result of the prevailing fire regime was a savanna-like landscape composed of groups and single trees interspersed by large openings with grass being the primary cover.

Localized stand-destroying fires apparently took place during extreme conditions, but these fires appear to have been uncommon, judging from the lack of down tree trunks over appreciable areas. The prevailing open, savanna like landscapes were not conducive of sustaining high intensity fires. Thickening of the tree cover in the absence of fire suggests high intensity crown fires were more likely after the turn of the century.

MANAGEMENT IMPLICATIONS

Before EuroAmerican settlement, fire played a critical ecological role within the present boundaries of the Walker River Watershed Project. Following settlement by EuroAmericans, elimination of Indian fires and removal of fine fuels by livestock drastically altered the prevailing low intensity fire regime. Since the 1930's, fire suppression strategies have placed emphasis on aggressive attack of all fires. Ninety percent of the fires occurring in the project area from 1960-1996 have been held under one-quarter acre. Judging from photo retakes here and elsewhere in the Great Basin (Gruell 1966, Rogers 1982, Gruell 1995), this strategy has resulted in an unprecedented buildup of woody fuels that are susceptible to high intensity crown fire given extreme fire weather.

Current direction among land management agencies places emphasis on managing for a desired future condition within the range of natural variability. The most common reference point to identify desired future condition is the composition and structure of vegetation at the time of EuroAmerican settlement. As demonstrated by this study and others, many pinyon-juniper woodlands were historically savanna-like, containing a high complement of herbs and shrubs. This condition was an outcome of frequent, low intensity surface fires. These ecosystems and their disturbance regimes were conducive to perpetuating watershed stability and productive habitats for native wildlife. Following EuroAmerican settlement, they contributed significantly to the livestock forage base.

Forage production in pinyon-juniper woodlands has been reduced (Tausch et al. 1981, West 1988) because of the enormous increase in stand density. There is opportunity to stabilize watersheds, increase forage production, and minimize the threat of large, high intensity wildfires by reducing the density of pinyon-juniper. Cutting of trees followed by prescribed fire is a viable alternative in localities where there is a demand for the wood. Where fuels are sufficient to carry fire, prescriptions can be written that will allow attainment of a mosaic of different seral stages on the landscape. Preparation of a burn plan that utilizes natural ignitions, as covered in the 1996 Federal Wildland Fire Management Policy and Review, would go a long way towards achieving treatment objectives. The end result would be a breakup of hazardous fuel continuity and rejuvenation of watersheds.

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